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Two years of operation of the ultraviolet stellar spectrophotometer S59 in E.S.R.O.'s TD1A satellite

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A progress report is given of the current state of the investigation of the *ca.* 3500 spectra obtained during the life time of the satellite. A summary is presented of the *general* types of investigation, namely those which involve a study of major parts of the observational material, and the more *specific* investigations, which refer to selected stars or groups of stars, or to special lines or groups of lines.

1. Introduction

The Utrecht stellar spectrophotometer S59 in E.S.R.O.'s TD1A satellite has been described elsewhere (De Jager *et al.* 1974). The first observations with this successful instrument were obtained on 22 March, 1972 (star β Aur); this star was observed again at half yearly intervals till 22 March 1974, thus yielding an excellent opportunity for the calibration of the stability of the sensitivity of the instrument. The gas supply for the satellite's stabilization was exhausted on 7 May 1974, terminating the scientific activity of the satellite.

During these two years some 3500 spectra were obtained of about 200 bright stars, most of early spectral types. The software for the processing of the observational material has been developed in the meantime, and it is expected that all observational data will be received from E.S.O.C. (E.S.R.O.'s Operation Centre at Darmstadt) at Utrecht in the course of summer 1975, and will be ready for study a few months later. An atlas of all stellar spectra will be published by the end of 1975. In the meantime, a fair number of publications have been issued, part of them only of an orientational character, and five doctor's theses on this material are in preparation in the Netherlands. More than 30 groups will receive part of the material for a scientific discussion. The *photometric stability* of the instrument could be investigated through repeated observations of the same stars, in which β Aurigae was the main gauge star. A sudden decrease of the u.v. sensitivity of slightly less than 10 % has been observed (table 1); it occurred during the winter period 1972/3. Final data can only be given at the end of 1975 when all material has been received.

Absolute calibration was obtained by laboratory measurements and by comparison with other observations and theoretical predictions (see Van der Hucht & Lamers 1974).

2. General analysis of the material

Progress reports on the various investigations on the S59 material have been presented at the 16th COSPAR meeting in Konstanz, BRD, summer 1973. Here we give only a brief summary.

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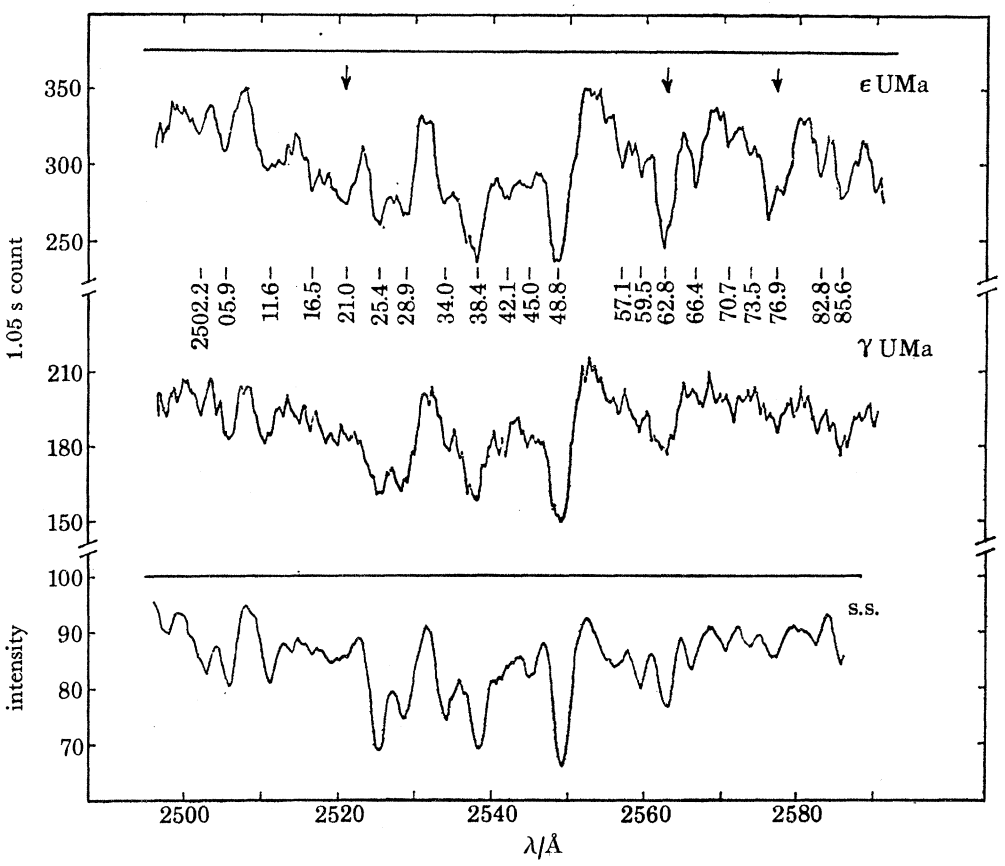

FIGURE 1. Synthetic spectrum as compared with observed spectra of ε UMa and γ UMa (Burger & Van der Hucht, 1974).

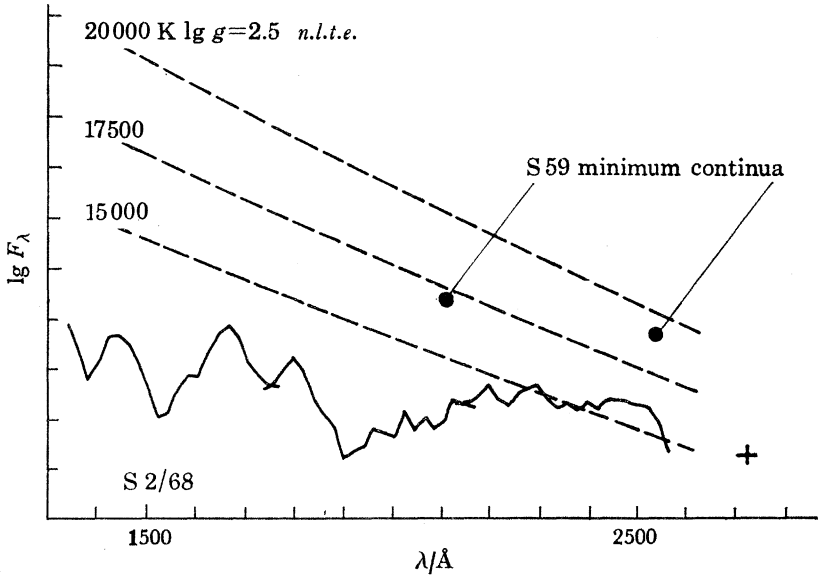

FIGURE 2. Minimum level of the continuous spectrum in o^2 CMa (B3Ia) as compared with (*a*) lower resolution spectra (S2/68) and (*b*) predicted continua for model photospheres (Mihalas 1972).

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A general process of *identification* of the lines in nine characteristic spectra is in progress in cooperation with the Trieste group (M. Hack, R. Faraggiana & R. Stalio). This will result in standard lists of wavelengths and identifications for these 'standard stars', and it is hoped that this material will be helpful to those analysing other spectra obtained with the same instrument. At the same time the measurement of equivalent widths of characteristic lines and flux ratios in continuum windows in the spectra of all S59 stars will enable the authors to define new u.v. classification criteria for early type stars, and to compare the results with those from visual spectra.

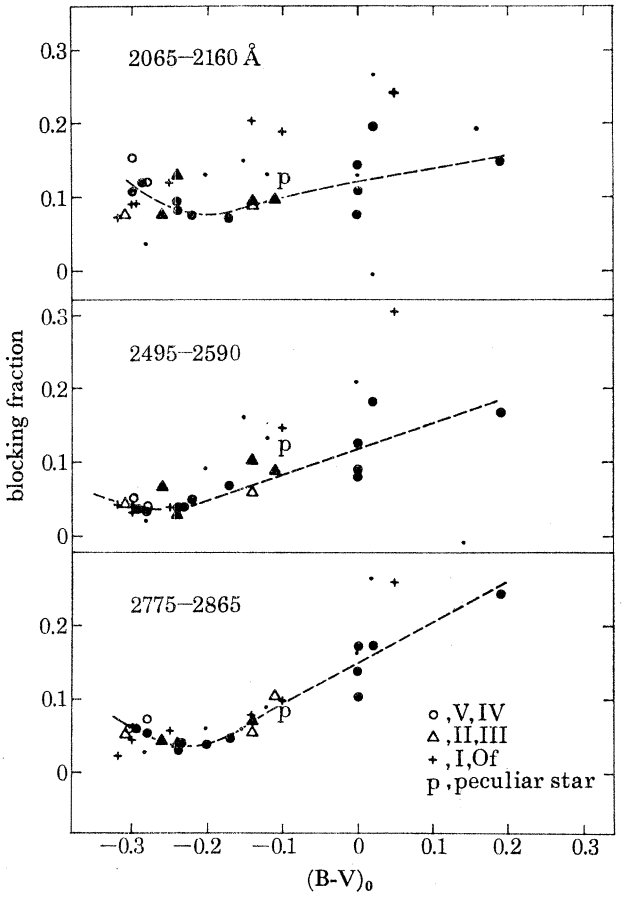

FIGURE 3. Minimum line blocking fraction in the three wavelength bands (Lamers *et al.* 1974). The dots refer to data from Underhill (1972).

Parallel to this, methods have been developed for a theoretical prediction of the spectra of the stars in the three wavelength bands observed with the satellite. Such *synthetic spectra* (see figure 1) published by M. Burger & K. A. van der Hucht (1974) have shown their usefulness, first of all for reliable determination of photospheric abundances, but also because in such a way unambiguous information is obtained on the amount of line blocking in the ultraviolet. Such computations give clearer information on the height of the 'continuous spectrum', which appears to be much higher than if drawn, as is customary, through the 'highest points between the lines' – at least for the main sequence stars of type B 5 and later, with S59-resolution. The influence of such effects on derived photospheric parameters of stars is shown in figure 2, where S2-68 data and S59 data are compared with model flux computations of Mihalas. In

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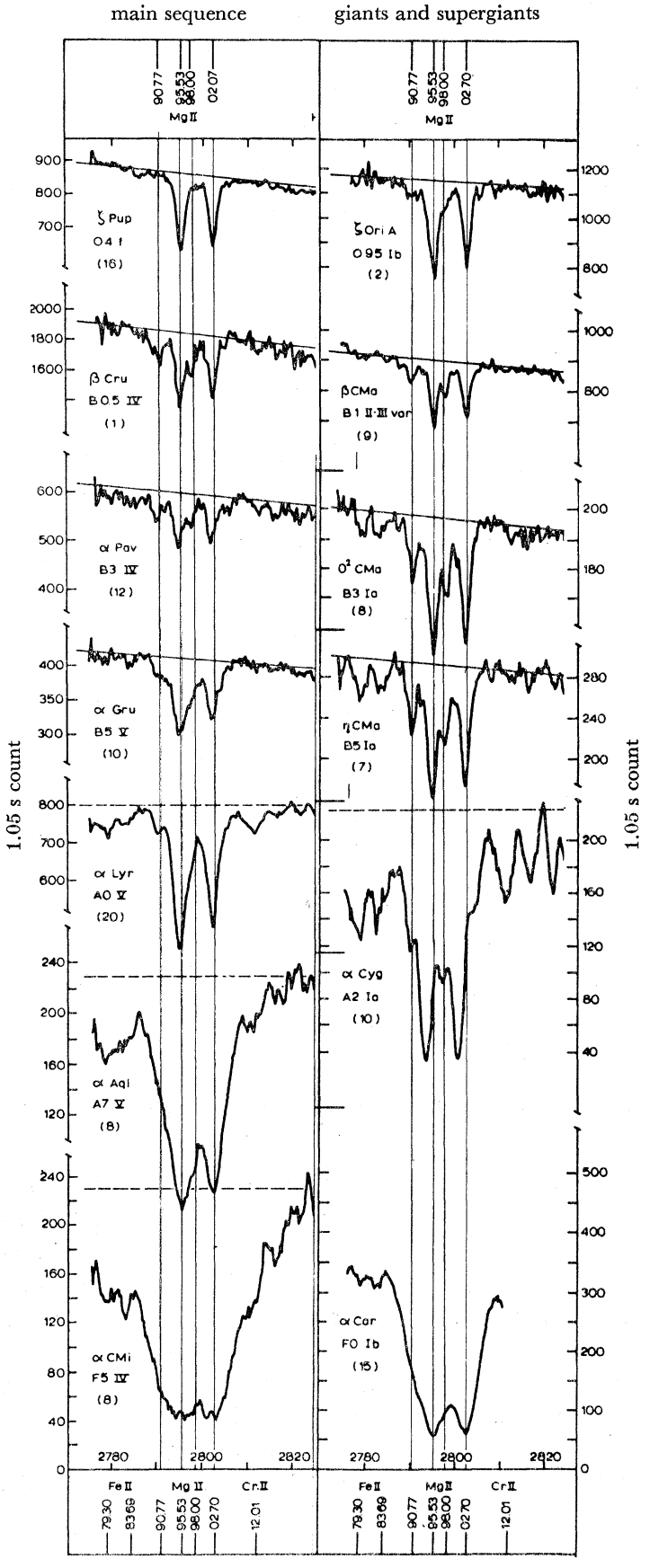

FIGURE 4. Mg II lines in bright stars. The shortward displacement in α Cyg (A2Ia), indicating outstreaming motions, is obvious.

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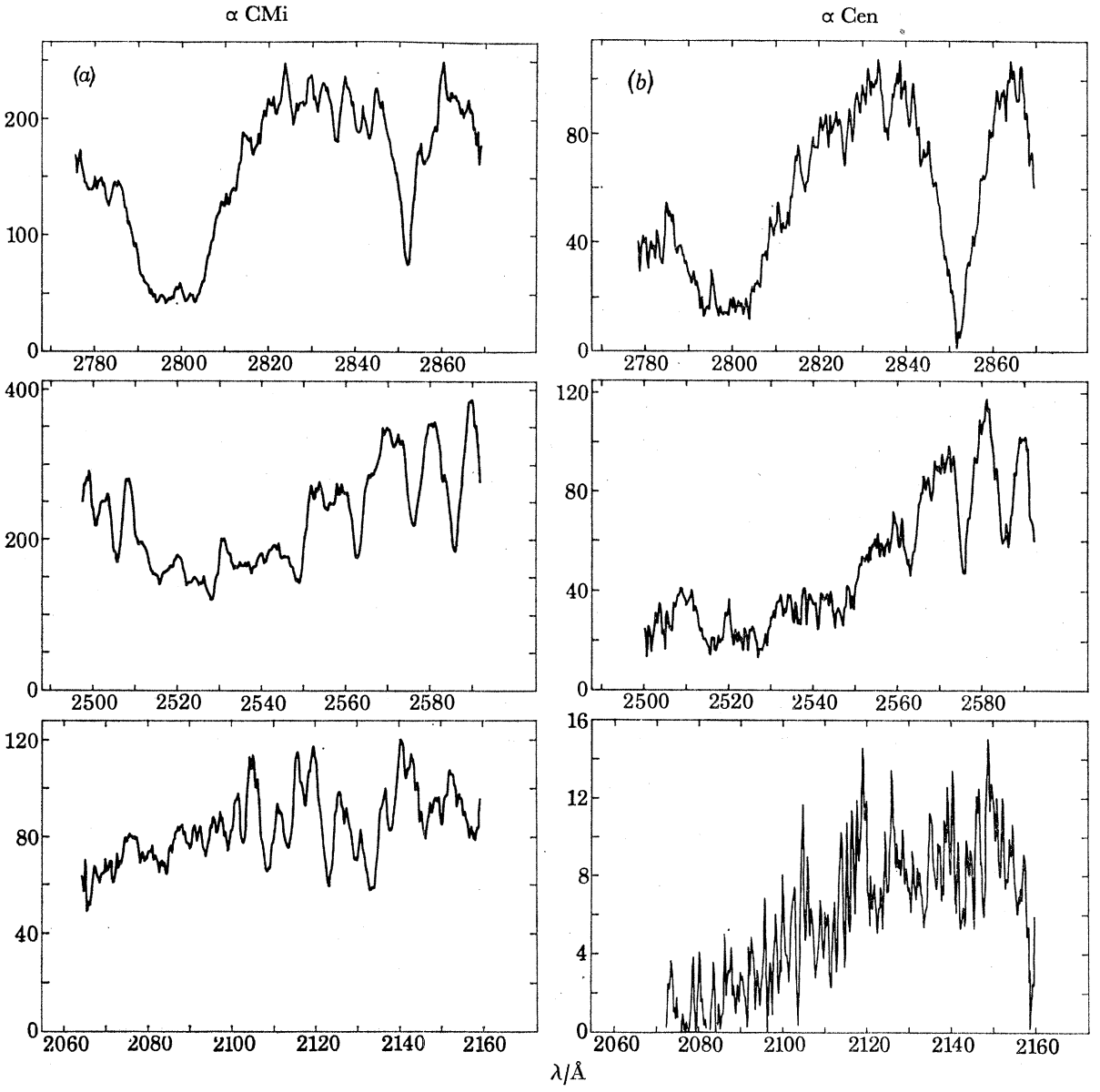

FIGURE 5. Spectra of two 'solar type' main sequence stars (α CMi F5II, and α Cen G2V), showing among other things the 'Al-discontinuity' near 2100 Å.

TABLE 1. OVERALL SENSITIVITY OF S59 SPECTROMETER IN 1973 AS COMPARED WITH 1972

		1973 efficiency/1972 efficiency (%)		
star	date of observation	2100 Å channel	2500 Å channel	2800 Å channel
β Aur	20 March	93.7	91.5	88.3
β CMa	27 March	91.2	89.5	89.3
ζ CMa	28 March	94.5	90.9	90.5
λ Gem	29 March	92.4	89.3	89.0
φ Sgr	29 March	—	91.4	—
ζ Pup	9 May	88.2	89.1	89.1
λ Vel	18 May	89.8	91.2	90.7
	averaged values:	91.6%	90.4%	89.5%

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figure 3 the lower limits of the line blocking in the three wavelength bands is given (Lamers *et al.* 1974).

Computations of such synthetic spectra are now under way by M. Burger (peculiar A-type stars), Heintze & Sakhibullin (early type stars), de Jager & Neven (B 2-, 3-type stars and F–G type stars), Sakhibullin & Lamers (supergiants).

3. More specific investigations

Apart from the more general investigations described above, a number of more specific research topics are mentioned briefly; no attempt is made to be complete.

Mg II *lines at* 2800 Å

The doublet is a major spectral feature in nearly *all* stellar spectra under investigation (see figure 4). A start of a theoretical calculation of these lines on a non-l.t.e. basis was made by Sakhibullin while he was on leave from Kazan University (U.S.S.R.) in Utrecht. The work was finished later by Snijders & Lamers, and it forms part of the former's doctoral thesis. Generally speaking, it seems well possible to represent the observed equivalent widths of the lines and their variation across the spectral types by non-l.t.e. calculations, if an abundance ratio $\mathrm{Mg/H} = 3 \times 10^{-5}$ is adopted (Lamers, Van der Hucht, Snijders & Sakhibulin 1973; Snijder & Lamers 1974).

A non-l.t.e. investigation of C II, III and IV *lines* in early type stellar spectra is in progress by N. Sakhibullin of Kazan University (U.S.S.R.), now on leave at Utrecht.

Wolf-Rayet and O-type stars

This investigation is under way by K. A. van der Hucht. Part of his results will be reported in this meeting.

Peculiar A-type stars

A first report of these investigations was given in Konstanz by Mrs Burger & K. A. van der Hucht (1974).

β *Canis Maioris stars*

This curious group of pulsating stars with a small brightness amplitude in the visual spectral range has spectral types B2–B3 and luminosity classifications II–IV. An inspection of their brightness fluctuations in the near ultraviolet shows that the amplitude seems to *in*crease with *de*creasing wavelength. Spectra of a ten of these stars are under investigation by De Jager & Neven.

Instable supergiants and outstreaming motions

These are the subject of an investigation by H. J. Lamers. Part of it, referring to the S59 observations of α Cygni, are reported in this meeting.

Medium type stars (F–G)

Only the brightest F- and G-type stars have sufficient u.v. luminosity to be observable with S59 (figure 5). A comparison with the solar spectrum is the obvious thing to do and will be performed by De Jager & Neven, on the basis of rocket observation of the solar near u.v. spectrum as obtained by Bonnet.

An interesting feature in the solar u.v. spectrum near 2100 Å is the so-called *Al-discontinuity*.

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It is also clearly visible in the spectra of α Cen (G2V) and α CMi (F5 II). This feature will be studied by Bonnet.

Finally we briefly mention various smaller investigations either under way or finished, such as the investigation of *interstellar lines* by the groups in Bonn and Groningen, the spectral variations of β *Lyrae* (figure 6) and others.

All together S59 has been a wonderful piece of craftmanship that has well served its purpose.

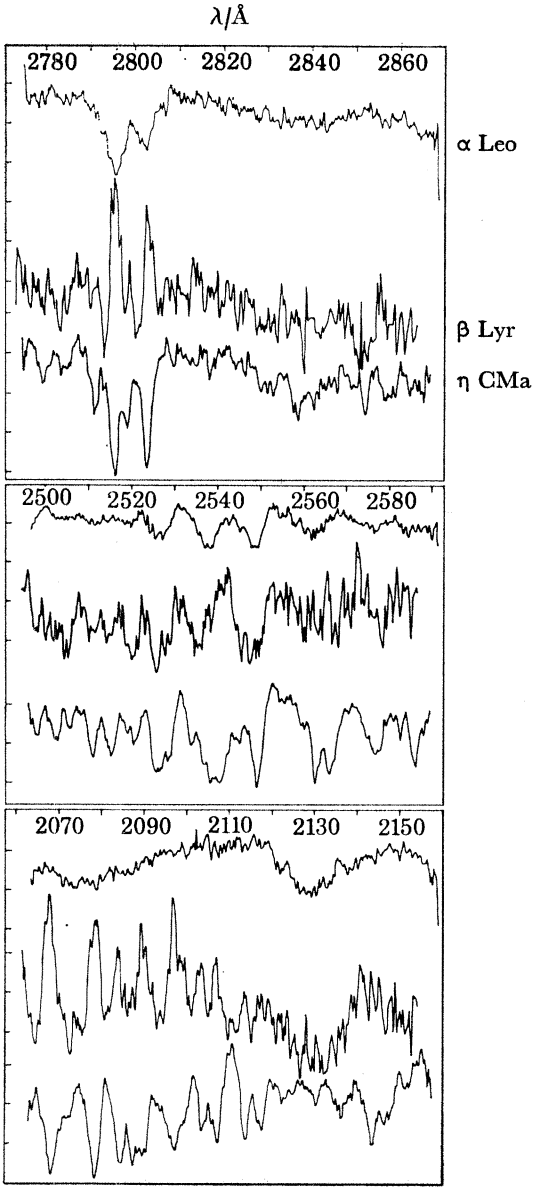

FIGURE 6. The spectrum of β Lyrae (B7V) as compared with α Leo (B7V) and η CMa (B5Ia). The general aspect of the spectrum of β Lyrae resembles more a supergiant than a main sequence star. The Cygni-type character of the Mg II lines is an interesting feature.

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